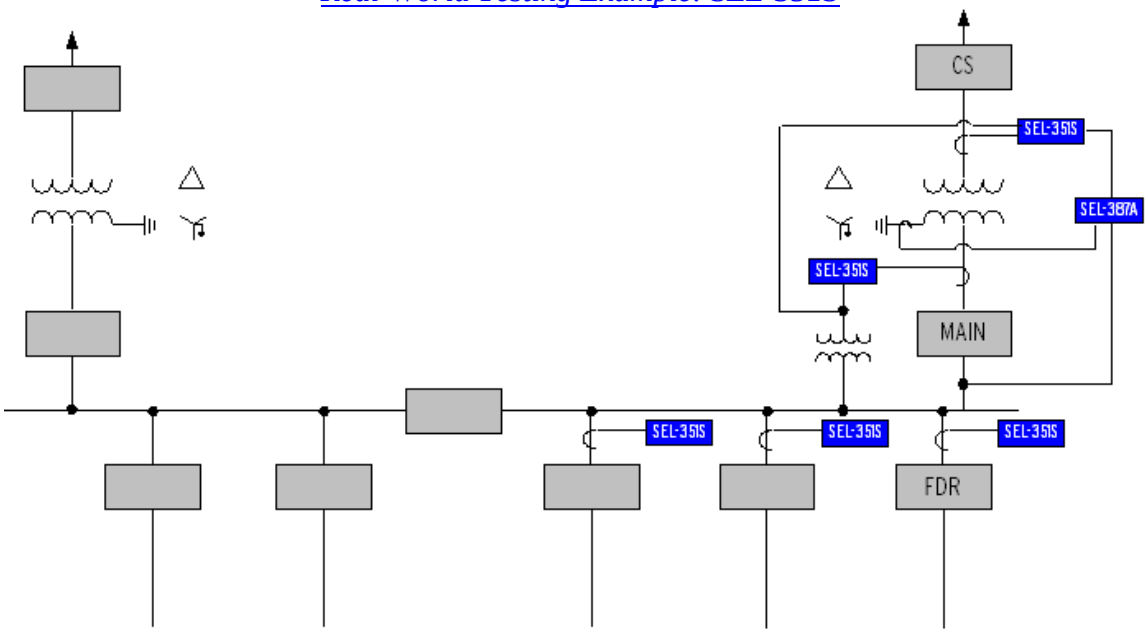
## Main Relay Commissioning Worksheet

*Real-World Testing Example: SEL-351S*




**Relay Setting File Name**: *MAIN_rev*
**Active AcSELerator Database Name**:
*Substation Settings_rev.RDB*
**AcSELerator Version Used to Create DB**:
*4.1.10.0*
**Directory Where Settings Stored**: *…_rev.rdb*

**Functional Description**:
Protection for this main breaker consists of non-directional phase 51P, ground 51G, fast bus trip scheme (67P1T and 67G1T, 6 cycle delay, trips if IN104 is not asserted), and undervoltage (27, 1 sec delay, supervised by loss-of-potential and main breaker status) load shedding. 51 Relay trips are via OUT101, fast bus trips are via OUT103, and undervoltage trips are via OUT104. All trips light the TRIP LED. 51P settings are pick-up of 5 A, U3 curve, TD = 2.5, and no e/m reset. 51G settings are pick-up of 2.5 A, U3 curve, TD = 2.5, and no e/m reset. 67P1 is set for 12.5 A, and 67G1 is set for 6.25 A. Undervoltage settings are for 96 Vsec, any phase. No automatic reclosing is enabled in this relay.

Two front panel push buttons are used (PB3, SUPERVISORY DISABLED = AMBER, and LOCK, which supervises the operation of PB3). Auxiliary red and green push buttons are used to provide local manual trip and close.

SCADA controls are used to trip (uses OC bit, and OUT106) and close (uses CC bit, and OUT107), when supervisory push button allows. SCADA trip and close are done through SELogic variables with 30 cycle drop-out delay.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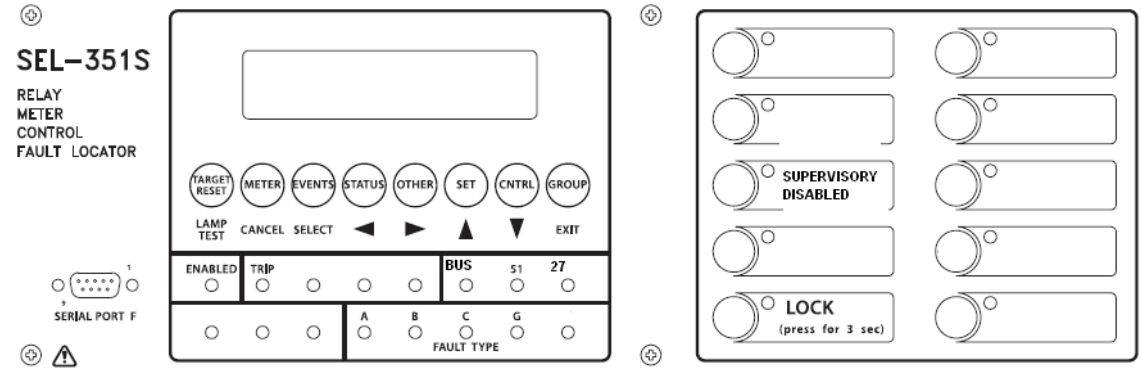
Front panel display messages describe a variety of monitored elements and push button status. Monitored inputs include breaker status (IN101), breaker position (IN102), supervisory enable (LT3), tie breaker status (IN105), lockout relay status (IN103), and received fast bus trip scheme block (IN104). OUT102 is closed when the main breaker is open (allows CS closure) and OUT105 follows the status of the bus tie breaker.




Download Settings From Database? *P1-3, G, G1, L1, SER, TEXT.*

Compare Settings in Relay to Database. No Errors? *(Read to "As Set" File Name). OK!*

COPY GROUP 1 TO ALL SIX? *YES.*

Replaced Default Front Panel Labels? *YES.*

Settings (insert screen capture here of Group 1, Logic 1, Global, SER, Text and Port):

=>>SHO G

Global Settings:
PTCONN = WYE VSCONN = VS TGR = 180.00
NFREQ = 60 PHROT = ABC DATE_F = MDY
FP_TO = 15 SCROLD = 2 FPNGD = IG
LER = 15 PRE = 4 DCLOP = OFF DCHIP = OFF
IN101D = 0.50 IN102D = 0.50 IN103D = 0.50 IN104D = 0.50
IN105D = 0.50 IN106D = 0.50
EBMON = N
LED12L = Y LED13L = N LED14L = N LED15L = N
LED16L = Y LED17L = Y LED18L = Y LED19L = N
LED20L = N LED21L = N LED25L = Y LED26L = N
RSTLED = Y
PB9D = 0.00 PB10D = 0.00
EPMU = N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```
=>>SHO
Group 1
Group Settings:

RID    =MAIN BKR 8                TID    =CENTRAL
CTR    = 320      CTRN   = 1
PTR    = 60.00    PTRS   = 1.00     VNOM   = 120.00
Z1MAG  = 0.10     Z1ANG  = 5.00     Z0MAG  = 0.10     Z0ANG  = 5.00
LL     = 0.10
E50P   = 1        E50N   = N        E50G   = 1        E50Q   = N
E51P   = 1        E51N   = N        E51G   = 1        E51Q   = N
E32    = N        ELOAD  = N        ESOTF  = N        EVOLT  = Y
E25    = N        EFLOC  = N        ELOP   = Y        ECOMM  = N
E81    = N        E79    = N        ESV    = 3        EDEM   = THM
50P1P  = 12.50
67P1D  = 6.00
50PP1P = OFF
50G1P  = 6.250
67G1D  = 6.00
51P1P  = 5.00     51P1C  = U3       51P1TD = 2.50     51P1RS = N
51P1CT = 0.00     51P1MR = 0.00

Press RETURN to continue
51G1P  = 2.50     51G1C  = U3       51G1TD = 2.50     51G1RS = N
51G1CT = 0.00     51G1MR = 0.00
27P1P  = 96.00    27P2P  = OFF      59P1P  = OFF      59P2P  = OFF
59N1P  = OFF      59N2P  = OFF      59QP   = OFF
59V1P  = OFF      27SP   = OFF      59S1P  = OFF      59S2P  = OFF
27PP   = OFF      59PP   = OFF
DMTC   = 5
PDEMP  = OFF      NDEMP  = OFF      GDEMP  = OFF      QDEMP  = OFF
TDURD  = 9.00     CFD    = 60.00    3POD   = 1.50     50LP   = 0.25
SV1PU  = 60.00    SV1DO  = 60.00    SV2PU  = 0.00     SV2DO  = 30.00
SV3PU  = 0.00     SV3DO  = 30.00

=>>SHO L
SELogic group 1

SELogic Control Equations:
TR     =51P1T + 51G1T + SV1T + 67P1T + 67G1T
TRCOMM =0
TRSOTF =0
DTT    =0
ULTR   =!(51P1 + 51G1)
PT1    =0
LOG1   =0
PT2    =0
LOG2   =0
BT     =0
52A    =IN101
CL     =0
ULCL   =1
79RI   =0
```


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```
79RIS  =0
79DTL  =1
79DLS  =1

Press RETURN to continue
79SKP  =0
79STL  =1
79BRS  =0
79SEQ  =0
79CLS  =0
SET1   =0
RST1   =0
SET2   =0
RST2   =0
SET3   =!LT3 * PB3 * LT4
RST3   =LT3 * PB3 * LT4
SET4   =!LT4 * PB5
RST4   =LT4 * PB5
SET5   =0
RST5   =0
SET6   =0
RST6   =0
SET7   =0
RST7   =0
SET8   =0

Press RETURN to continue
RST8   =0
SET9   =0
RST9   =0
SET10  =0
RST10  =0
SET11  =0
RST11  =0
SET12  =0
RST12  =0
SET13  =0
RST13  =0
SET14  =0
RST14  =0
SET15  =0
RST15  =0
SET16  =0
RST16  =0
67P1TC =!IN104
67P2TC =1
67P3TC =1

Press RETURN to continue
67P4TC =1
67N1TC =1
67N2TC =1
67N3TC =1
```


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```
67N4TC =1
67G1TC =!IN104
67G2TC =1
67G3TC =1
67G4TC =1
67Q1TC =1
67Q2TC =1
67Q3TC =1
67Q4TC =1
51P1TC =1
51N1TC =1
51G1TC =1
51P2TC =1
51N2TC =1
51G2TC =1
51QTC  =1

Press RETURN to continue

SV1    =(27A1 + 27B1 + 27C1) * !LOP * 52A
SV2    =OC * LT3
SV3    =CC * LT3
SV4    =0
SV5    =0
SV6    =0
SV7    =0
SV8    =0
SV9    =0
SV10   =0
SV11   =0
SV12   =0
SV13   =0
SV14   =0
SV15   =0
SV16   =0
OUT101 =TRIP * (51P1T + 51G1T)
OUT102 =!IN101
OUT103 =TRIP * (67P1T + 67G1T)
OUT104 =TRIP * SV1T

Press RETURN to continue
OUT105 =IN105
OUT106 =SV2T
OUT107 =SV3T
LED1   =0
LED2   =0
LED3   =!LT3
LED4   =0
LED5   =!LT4
LED6   =0
LED7   =0
LED8   =0
LED9   =0
```


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```
LED10  =0
LED12  =TRIP
LED13  =0
LED14  =0
LED15  =0
LED16  =67P1T + 67G1T
LED17  =51P1T + 51G1T
LED18  =SV1T

Press RETURN to continue

LED19  =0
LED20  =0
LED21  =0
LED25  =51G1
LED26  =0
DP1    =IN101
DP2    =IN102
DP3    =IN103
DP4    =IN104
DP5    =IN105
DP6    =LT3
DP7    =0
DP8    =0
DP9    =0
DP10   =0
DP11   =0
DP12   =0
DP13   =0
DP14   =0
DP15   =0

Press RETURN to continue
DP16   =0
SS1    =1
SS2    =0
SS3    =0
SS4    =0
SS5    =0
SS6    =0
ER     =/51P1 + /51G1 + /67P1 + /67G1 + /27A1 + /27B1 + /27C1
FAULT  =51P1 + 51G1
BSYNCH =1
CLMON  =0
BKMON  =0
E32IV  =0
TMB1A  =0
TMB2A  =0
TMB3A  =0
TMB4A  =0
TMB5A  =0
TMB6A  =0
TMB7A  =0
```


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```
Press RETURN to continue

TMB8A  =0
TMB1B  =0
TMB2B  =0
TMB3B  =0
TMB4B  =0
TMB5B  =0
TMB6B  =0
TMB7B  =0
TMB8B  =0

=>>SHO R

Sequential Events Recorder trigger lists:
SER1
=51P1,51G1,67P1T,67G1T,OUT101,OUT102,OUT103,OUT104,OUT105,OUT106,OUT1
07
SER2   =IN101,IN102,IN103,IN104,IN105,OC,CC,52A,TRIP,CLOSE
SER3   =SV1,SV2,SV3,SV1T,SV2T,SV3T,27A1,27B1,27C1,51P1T,51G1T,67P1,67G1

Load Profile settings:
LDLIST =0
LDAR   = 15


=>>SHO T

Text Labels:
NLB1   =          CLB1   =      SLB1   =      PLB1   =
NLB2   =          CLB2   =      SLB2   =      PLB2   =
NLB3   =          CLB3   =      SLB3   =      PLB3   =
NLB4   =          CLB4   =      SLB4   =      PLB4   =
NLB5   =          CLB5   =      SLB5   =      PLB5   =
NLB6   =          CLB6   =      SLB6   =      PLB6   =
NLB7   =          CLB7   =      SLB7   =      PLB7   =
NLB8   =          CLB8   =      SLB8   =      PLB8   =
NLB9   =          CLB9   =      SLB9   =      PLB9   =
NLB10  =          CLB10  =      SLB10  =      PLB10  =
NLB11  =          CLB11  =      SLB11  =      PLB11  =
NLB12  =          CLB12  =      SLB12  =      PLB12  =
NLB13  =          CLB13  =      SLB13  =      PLB13  =
NLB14  =          CLB14  =      SLB14  =      PLB14  =
NLB15  =          CLB15  =      SLB15  =      PLB15  =
NLB16  =          CLB16  =      SLB16  =      PLB16  =
DP1_1  =BREAKER CLOSED   DP1_0  =BREAKER OPEN

Press RETURN to continue
DP2_1  =BKR RACKED IN    DP2_0  =BKR RACKED OUT
DP3_1  =86B LOCKOUT TRIP DP3_0  =
DP4_1  =FAST BUS BLOCK   DP4_0  =
DP5_1  =TIE BKR CLOSED   DP5_0  =TIE BKR OPEN
```


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```
DP6_1  =SUPERVISORY ON   DP6_0  =SUPERVISORY OFF
DP7_1  =                 DP7_0  =
DP8_1  =                 DP8_0  =
DP9_1  =                 DP9_0  =
DP10_1 =                 DP10_0 =
DP11_1 =                 DP11_0 =
DP12_1 =                 DP12_0 =
DP13_1 =                 DP13_0 =
DP14_1 =                 DP14_0 =
DP15_1 =                 DP15_0 =
DP16_1 =                 DP16_0 =
79LL   =              79SL   =

=>>SHO P 2
Port 2

PROTO  = SEL
SPEED  = 9600     BITS   = 8       PARITY = N       STOP   = 1
T_OUT  = 0        AUTO   = Y       RTSCTS = N       FASTOP = Y
```

**Metering Check** *(insert screen capture here):*

CTR = 320
Inom = 5 A
PTR = 60
Vnom = 120 V Line-Neutral
With 5A and 120V, 3PH, Balanced Applied

```
=>>METER
MAIN BKR 8                              Date: 06/13/07    Time: 09:18:56.304
CENTRAL
                        A          B          C          N          G
I MAG (A)           321.845    320.658    324.514      0.000      6.522
I ANG (DEG)          -9.96    -130.52     109.49      84.74      86.60

                        A          B          C          S
V MAG (KV)            7.287      7.282      7.291      0.000
V ANG (DEG)           0.00    -120.04     119.96     107.70

                        A          B          C         3P
MW                    2.310      2.296      2.327      6.933
MVAR                  0.406      0.425      0.430      1.261
PF                    0.985      0.983      0.983      0.984
                      LAG        LAG        LAG        LAG

                       I1         3I2        3I0         V1         V2         3V0
MAG                 322.336      0.732      6.522      7.287      0.001      0.012
ANG   (DEG)          -10.33    -174.14      86.60      -0.02     -80.24      86.80

FREQ (Hz)           60.01                  VDC (V)        18.3
=>>
```

Test Manual Close? *YES. (red push button)*

Does HS CS=Open Block Main Breaker Close? *YES. (i.e. CS only can energize xfmr)*


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Does Position Indicator Work (RED LED)? *YES.*

Test Manual Trip? *YES. (green push button)*

Does Position Indicator Work (GRN LED)? *YES.*

**Test Pick-Ups**

Use Target Command.

51P = 5 A expected. Actual? *5.00 a*
(Inject A phase)

51G = 2.5 A expected. Actual? *2.50 a*
(Inject B phase = 3IO)

67P1 = 12.5 A Expected. Actual? *12.37 a*
(Inject C phase)

67G1 = 6.25 A Expected. Actual? *6.26 a*
(Inject A Phase = 3IO)

27P1 = 96 V Expected. Actual? *94.80 V*
(Reduce All Three Phase Voltages)

**Test Time and Curve:**

Use SER.

@ 3 x times Tap (15A), Expected 51P Time = 1.4532 sec. Actual? *1.437 SEC*
(Inject B Phase)

@ 3 x times Tap (7.5A), Expected 51G Time = 1.4532 sec. Actual? *1.416 SEC*
(Inject 2.5 @ 0 deg on A,B,C Phases)

U3 (Very Inverse) $t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$

Inject the Same Current @ 13 A Balanced Into a Feeder Relay and The Bus Main FOR 1 SEC. Fast Bus Should Not Trip. *Yes.*
Inject Same Current Into Bus Main Only, Bus Should Trip (67P1T) Expected in 6 Cycles. Actual? *Yes.*

Inject the Same Current @ 7 A Into a Feeder Relay and The Bus Main. Fast Bus Should Not Trip. *Yes.*
Inject Same Current Into Bus Main Only, Bus Should Trip (67G1T) Expected in 6 Cycles. Actual? *Yes.*
(Inject C Phase = 3I0)
Does Display Point Report When Blocking is Received? *Yes.*


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Reduce Phase Voltage from Nominal to 95 Volts on A Phase. 27 Trip Via SV1T Expected in 60 Cycles. Actual? *Yes.*
(Use A Phase)

**Test Inputs**

Change State of Breaker.
Does TARGET Command Follow IN101 Correctly? IN101 = 1 = Breaker Closed,
IN101 = 0 = Breaker Open? *Yes.*
Does Front Panel Display Message Correctly Follow Breaker Status? *Yes.*
Rack Breaker In and Out.
Does TARGET Command Follow IN102 Correctly? IN102 = 1 = Breaker racked
IN, IN102 = 0 = Breaker racked out? *Yes.*
Does Front Panel Display Message Correctly Follow Breaker Position? *Yes.*

**Test SCADA Control**

Is Supv Disabled LED AMBER in Disabled Position? *Yes.*
Does Front Panel Message Follow? *Yes.*

Assert OC Bit.
Does BKR Open (when Supv is Enabled)? *Yes.*
Does BKR Not Open (When Supv is Disabled)? *Yes.*
Use SER.
Does OUT106 Remain Closed for 0.5 sec? *Yes.*

Assert CC Bit.
Does BKR Close (when Supv is Enabled)? *Yes.*
Does BKR Not Close (When Supv is Disabled)? *Yes.*
Does Main Breaker=Closed Block HS CS Close? Yes. (i.e. CS only can energize xfmr)
Does HS CS=Open Block Main Breaker Close? *Yes.* (i.e. CS only can energize xfmr)
Use SER. Does OUT107 Remain Closed for 0.5 sec? *Yes.*

Does OUT105 Close When the Tie Breaker Is Closed? *YES*
Does Display Point Follow Tie Breaker Status? *Yes*

Does OUT102 Close When the Main Breaker Is Open? *Yes.*
Does Display Point Follow Main Breaker Status? *Yes.*

Does INPUT 103 Assert When 86B Lockout Trips? *Yes.*
Does Display Point Follow 86B Status? *Yes.*

Does Trip LED Assert for any Trip Condition (51, Fast Bus, 27)? *Yes.*

Does Alarm Contact Operate? *Yes.*

**Last Steps (After All Testing is Complete) -**

Have Drawings Been Highlighted (All Inputs/Outputs Tested) and Redlined (Changes)? *Yes. (need to wire OUT104 for 27)*


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Remove AMS Cable, Check Relay Ribbon Connection? *Yes.*
Reset Event History? *Yes.*
Reset SER? *Yes.*
Read As-Left Relay Settings? *Yes.*
Record Setting File Name? *Main_m8_rev_as left*


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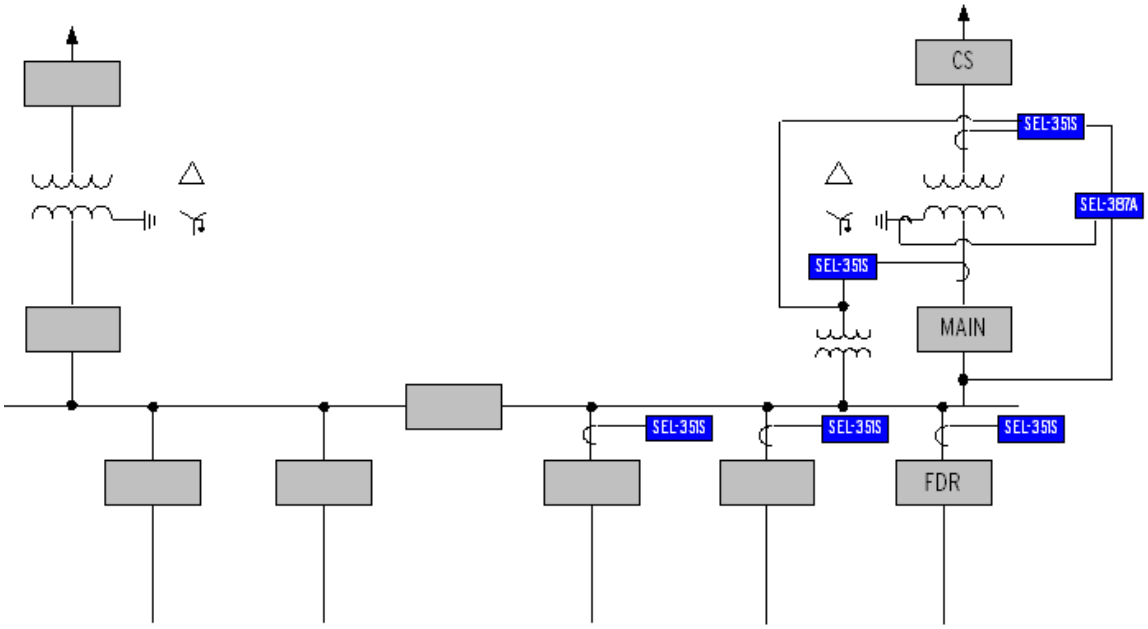
## HS Backup Commissioning Worksheet

*Real-World Testing Example: SEL-351S*




**Relay Setting File Name:** *Primary Backup_rev*
**Active AcSELerator Database Name:**
*Substation Settings_rev.RDB*
**AcSELerator Version Used to Create DB:**
*4.1.10.0*
**Directory Where Settings Stored:** *…_rev.rdb*

**Functional Description:**
Protection for this relay consists of non-directional phase 51P, ground 51G, instantaneous phase 50P, and instantaneous ground 50G. Relay trips are via OUT101. When the HS Circuit Switcher is tripped or open, we also trip the main.

51P settings are pick-up of 2.4 A, U3 curve, TD = 3, and no e/m reset.
51G settings are pick-up of 1.2 A, U3 curve, TD = 3, and no e/m reset.
50P1 settings are 14 A pick-up, no time delay, and 50G1 settings are 10 A pick-up (3I0), no time delay.

There is no automatic reclosing for this relay.

Two front panel push buttons are used (SUPERVISORY DISABLED = AMBER, and LOCK, which supervises the operation of PB3). Auxiliary red and green push buttons are used to provide local manual trip and close.

SCADA controls are used to trip (uses OC bit, and OUT106) and close (uses CC bit, and OUT107), when supervisory push button allows. SCADA trip and close are done through SELogic variables with 30 cycle drop-out delay. Closing the high-side circuit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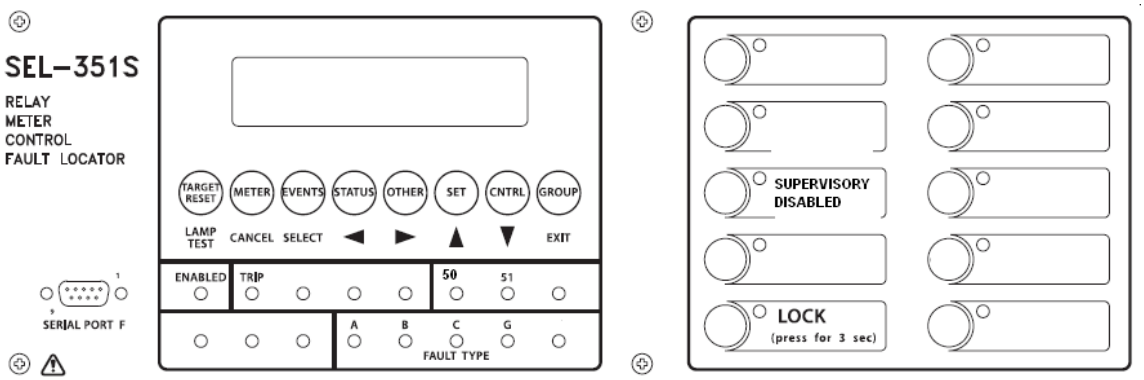
switcher can only be done when the low-side main breaker is open. (Closing the low-side main can only be done when the high-side is closed.)

Front panel display messages describe a variety of monitored elements and push button status. Monitored inputs include circuit switcher status (IN101), main breaker status (IN102), supervisory enable, and 86A.




**Download Settings From Database?** *P1-3, G, G1, L1, SER, TEXT.*

**Compare Settings in Relay to Database. No Errors?** *(Read to "As Set" File Name). OK!*

**COPY GROUP 1 TO ALL SIX?** *YES.*

**Replaced Default Front Panel Labels?** *YES.*

**Settings** *(insert screen capture here of Group 1, Logic 1, Global, SER, Text and Port):*

=>>SHO G

Global Settings:
PTCONN = WYE VSCONN = VS TGR = 180.00
NFREQ = 60 PHROT = ABC DATE_F = MDY
FP_TO = 15 SCROLD = 2 FPNGD = IG
LER = 15 PRE = 4 DCLOP = OFF DCHIP = OFF
IN101D = 0.50 IN102D = 0.50 IN103D = 0.50 IN104D = 0.50
IN105D = 0.50 IN106D = 0.50
EBMON = N
LED12L = Y LED13L = Y LED14L = Y LED15L = Y
LED16L = Y LED17L = Y LED18L = Y LED19L = N
LED20L = N LED21L = N LED25L = Y LED26L = Y
RSTLED = Y
PB9D = 0.00 PB10D = 0.00
EPMU = N

=>>SHO
Group 1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Group Settings:

```
RID    =CS10 BACKUP                TID    =CENTRAL
CTR    = 120      CTRN   = 1
PTR    = 600.00   PTRS   = 1.00     VNOM   = 66.40
Z1MAG  = 0.10     Z1ANG  = 5.00     Z0MAG  = 0.10     Z0ANG  = 5.00
LL     = 0.10
E50P   = 1        E50N   = N        E50G   = 1        E50Q   = N
E51P   = 1        E51N   = N        E51G   = 1        E51Q   = N
E32    = N        ELOAD  = N        ESOTF  = N        EVOLT  = N
E25    = N        EFLOC  = N        ELOP   = N        ECOMM  = N
E81    = N        E79    = N        ESV    = 3        EDEM   = THM
50P1P  = 14.00
67P1D  = 0.00
50PP1P = OFF
50G1P  = 10.000
67G1D  = 0.00
51P1P  = 2.40     51P1C  = U3       51P1TD = 3.00     51P1RS = N
51P1CT = 0.00     51P1MR = 0.00

Press RETURN to continue
51G1P  = 1.20     51G1C  = U3       51G1TD = 3.00     51G1RS = N
51G1CT = 0.00     51G1MR = 0.00
DMTC   = 5
PDEMP  = OFF      NDEMP  = OFF      GDEMP  = OFF      QDEMP  = OFF
TDURD  = 9.00     CFD    = 60.00    3POD   = 1.50     50LP   = 0.25
SV1PU  = 0.00     SV1DO  = 0.00     SV2PU  = 0.00     SV2DO  = 30.00
SV3PU  = 0.00     SV3DO  = 30.00

=>>
=>>SHO L
SELogic group 1

SELogic Control Equations:
TR     =51P1T + 51G1T + 50P1 + 50G1
TRCOMM =0
TRSOTF =0
DTT    =0
ULTR   =!(51P1 + 51G1)
PT1    =0
LOG1   =0
PT2    =0
LOG2   =0
BT     =0
52A    =IN101
CL     =0
ULCL   =1
79RI   =0
79RIS  =0
79DTL  =1
79DLS  =1

Press RETURN to continue
```


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```
79SKP  =0
79STL  =1
79BRS  =0
79SEQ  =0
79CLS  =0
SET1   =0
RST1   =0
SET2   =0
RST2   =0
SET3   =!LT3 * PB3 * LT4
RST3   =LT3 * PB3 * LT4
SET4   =!LT4 * PB5
RST4   =LT4 * PB5
SET5   =0
RST5   =0
SET6   =0
RST6   =0
SET7   =0
RST7   =0
SET8   =0

Press RETURN to continue

RST8   =0
SET9   =0
RST9   =0
SET10  =0
RST10  =0
SET11  =0
RST11  =0
SET12  =0
RST12  =0
SET13  =0
RST13  =0
SET14  =0
RST14  =0
SET15  =0
RST15  =0
SET16  =0
RST16  =0
67P1TC =1
67P2TC =1
67P3TC =1

Press RETURN to continue
67P4TC =1
67N1TC =1
67N2TC =1
67N3TC =1
67N4TC =1
67G1TC =1
67G2TC =1
67G3TC =1
```


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```
67G4TC =1
67Q1TC =1
67Q2TC =1
67Q3TC =1
67Q4TC =1
51P1TC =1
51N1TC =1
51G1TC =1
51P2TC =1
51N2TC =1
51G2TC =1
51QTC  =1

Press RETURN to continue

SV1    =0
SV2    =OC * LT3
SV3    =CC * LT3 * !IN102
SV4    =0
SV5    =0
SV6    =0
SV7    =0
SV8    =0
SV9    =0
SV10   =0
SV11   =0
SV12   =0
SV13   =0
SV14   =0
SV15   =0
SV16   =0
OUT101 =TRIP
OUT102 =IN101
OUT103 =!IN101 + TRIP
OUT104 =0

Press RETURN to continue
OUT105 =0
OUT106 =SV2T
OUT107 =SV3T
LED1   =0
LED2   =0
LED3   =!LT3
LED4   =0
LED5   =!LT4
LED6   =0
LED7   =0
LED8   =0
LED9   =0
LED10  =0
LED12  =TRIP
LED13  =0
LED14  =0
```


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```
LED15  =0
LED16  =50P1 + 50G1
LED17  =51P1T + 51G1T
LED18  =0

Press RETURN to continue

LED19  =0
LED20  =0
LED21  =0
LED25  =51G1
LED26  =0
DP1    =IN101
DP2    =IN102
DP3    =IN103
DP4    =LT3
DP5    =0
DP6    =0
DP7    =0
DP8    =0
DP9    =0
DP10   =0
DP11   =0
DP12   =0
DP13   =0
DP14   =0
DP15   =0

Press RETURN to continue
DP16   =0
SS1    =1
SS2    =0
SS3    =0
SS4    =0
SS5    =0
SS6    =0
ER     =/51P1 + /51G1
FAULT  =51P1 + 51G1
BSYNCH =1
CLMON  =0
BKMON  =0
E32IV  =0
TMB1A  =0
TMB2A  =0
TMB3A  =0
TMB4A  =0
TMB5A  =0
TMB6A  =0
TMB7A  =0

Press RETURN to continue

TMB8A  =0
```


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```
TMB1B  =0
TMB2B  =0
TMB3B  =0
TMB4B  =0
TMB5B  =0
TMB6B  =0
TMB7B  =0
TMB8B  =0

=>>SHO R

Sequential Events Recorder trigger lists:
SER1   =51P1,51P1T,51G1,51G1T,50P1,50G1,OUT101,TRIP
SER2   =OC,CC,SV2,SV2T,SV3,SV3T
SER3   =IN101,IN102,IN103,OUT102,OUT103,OUT106,OUT107

Load Profile settings:
LDLIST =0
LDAR   = 15

=>>SHO T

Text Labels:
NLB1   =          CLB1   =      SLB1   =      PLB1   =
NLB2   =          CLB2   =      SLB2   =      PLB2   =
NLB3   =          CLB3   =      SLB3   =      PLB3   =
NLB4   =          CLB4   =      SLB4   =      PLB4   =
NLB5   =          CLB5   =      SLB5   =      PLB5   =
NLB6   =          CLB6   =      SLB6   =      PLB6   =
NLB7   =          CLB7   =      SLB7   =      PLB7   =
NLB8   =          CLB8   =      SLB8   =      PLB8   =
NLB9   =          CLB9   =      SLB9   =      PLB9   =
NLB10  =          CLB10  =      SLB10  =      PLB10  =
NLB11  =          CLB11  =      SLB11  =      PLB11  =
NLB12  =          CLB12  =      SLB12  =      PLB12  =
NLB13  =          CLB13  =      SLB13  =      PLB13  =
NLB14  =          CLB14  =      SLB14  =      PLB14  =
NLB15  =          CLB15  =      SLB15  =      PLB15  =
NLB16  =          CLB16  =      SLB16  =      PLB16  =
DP1_1  =CS10 CLOSED     DP1_0  =CS10 OPEN

Press RETURN to continue
DP2_1  =M8 CLOSED       DP2_0  =M8 OPEN
DP3_1  =86A LOCKOUT TRIP DP3_0  =
DP4_1  =SUPERVISORY ON   DP4_0  =SUPERVISORY OFF
DP5_1  =            DP5_0  =
DP6_1  =            DP6_0  =
DP7_1  =            DP7_0  =
DP8_1  =            DP8_0  =
DP9_1  =            DP9_0  =
DP10_1 =            DP10_0 =
DP11_1 =            DP11_0 =
DP12_1 =            DP12_0 =
```


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```
DP13_1 =            DP13_0 =
DP14_1 =            DP14_0 =
DP15_1 =            DP15_0 =
DP16_1 =            DP16_0 =
79LL   =          79SL   =

=>>SHO P 2
Port 2

PROTO  = SEL
SPEED  = 9600     BITS   = 8       PARITY = N       STOP   = 1
T_OUT  = 0        AUTO   = Y       RTSCTS = N       FASTOP = Y
```

**Metering Check** *(insert screen capture here):*

CTR = 120
Inom = 5 A
PTR = 600
Vnom = 66.4 V Line-Neutral
With 1A and 120V, 3PH, Balanced Applied

```
=>>METER
CS10_BACKUP                              Date: 06/13/07    Time: 10:52:17.861
CENTRAL
                        A          B          C          N          G
I MAG (A)           120.629    121.079    120.626      0.000      1.289
I ANG (DEG)         -10.40     -130.61    109.92     167.66     -167.16

                        A          B          C          S
V MAG (KV)           40.312     40.307     40.325     0.000
V ANG (DEG)           0.00     -120.05    119.98     169.37

                        A          B          C         3P
MW                    4.783      4.798      4.789     14.370
MVAR                  0.878      0.894      0.850      2.622
PF                    0.984      0.983      0.985      0.984
                      LAG        LAG        LAG        LAG

                       I1        3I2        3I0         V1         V2         3V0
MAG                 120.777      0.790      1.289     40.315      0.005      0.044
ANG    (DEG)        -10.36      10.22    -167.16     -0.02      32.96     116.80

FREQ (Hz)           60.01                 VDC (V)        18.2
```

**Test Pick-Ups**

51P settings are pick-up of 2.4 A, U3 curve, TD = 3, and no e/m reset.
51G settings are pick-up of 1.2 A, U3 curve, TD = 3, and no e/m reset. 50P1 settings are 14 A pick-up, no time delay, and 50G1 settings are 10 A pick-up (3I0), no time delay.

Use Target Command.

51P = 2.4 A expected. Actual? *2.39 A*
(Inject A phase)

51G = 1.2 A expected. Actual? *1.22 a*
(Inject B phase)


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50P1 = 14 A expected. Actual? *13.97 A*
(Inject C phase)

50G1 = 10 A expected. Actual? *10 A*
(Inject 3.33 Amps on A, B, C phase @ 0 deg)

**Test Time and Curve:**

Use SER.

@ 3 x times Tap (7.2A), Expected 51P Time = 1.7439 sec. Actual? *1.708 sec*
(Inject A Phase)

@ 3 x times Tap (3.6A), Expected 51G Time = 1.7439 sec. Actual? *1.708 sec*
(Inject 1.2 @ 0 deg on A,B,C Phases)

| | |
|---|---|
| U3 (Very Inverse) | $t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$ |

@ > 14 A, Balanced three phase current, Does Relay Trip Instantly? *Yes.*

@ > 10 A on B-phase, Does Relay Trip Instantly? *Yes.*

Does the Main BKR Trip any time the CS is Opened? *Yes.*

**Test Inputs**

Change State of Main Breaker.
Does TARGET Command Follow IN102 Correctly? IN102 = 1 = Breaker Closed,
IN102 = 0 = Breaker Open? *Yes.*
Does Front Panel Display Message Correctly Follow Breaker Status? *Yes.*

**Test SCADA Control**

Is Supv Disabled LED AMBER in Disabled Position? *Yes.*
Does Front Panel Message Follow? *Yes.*

Assert OC Bit.
Does CS Open (when Supv is Enabled)? Yes.
Does BKR Not Open (When Supv is Disabled)? *Yes.*
Use SER.
Does OUT106 Remain Closed for 0.5 sec? *0.5 sec.*

Assert CC Bit.
Does BKR Close (when Supv is Enabled)? *Yes.*
Does BKR Not Close (When Supv is Disabled)? *Yes.*


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Does Main Breaker=Closed Block HS CS Close? *Yes. (i.e. CS only can energize xfmr)*
Does HS CS=Open Block Main Breaker Close? *Yes. (i.e. CS only can energize xfmr)*
Use SER.
Does OUT107 Remain Closed for 0.5 sec? *0.5 sec.*

Does Front Panel Report IN103 Status Correctly? (86A) *Yes.*

Does Alarm Contact Operate? *Yes.*

Last Steps (After All Testing is Complete) -

Have Drawings Been Highlighted (All Inputs/Outputs Tested) and Redlined (Changes)? *Yes.*

Remove AMS Cable, Check Relay Ribbon Connection? *Yes.*

Reset Event History? *YES.*
Reset SER? *YES.*
Read As-Left Relay Settings? *Yes.*
Record Setting File Name? *CS 10 Pri Backup_rev_as left*


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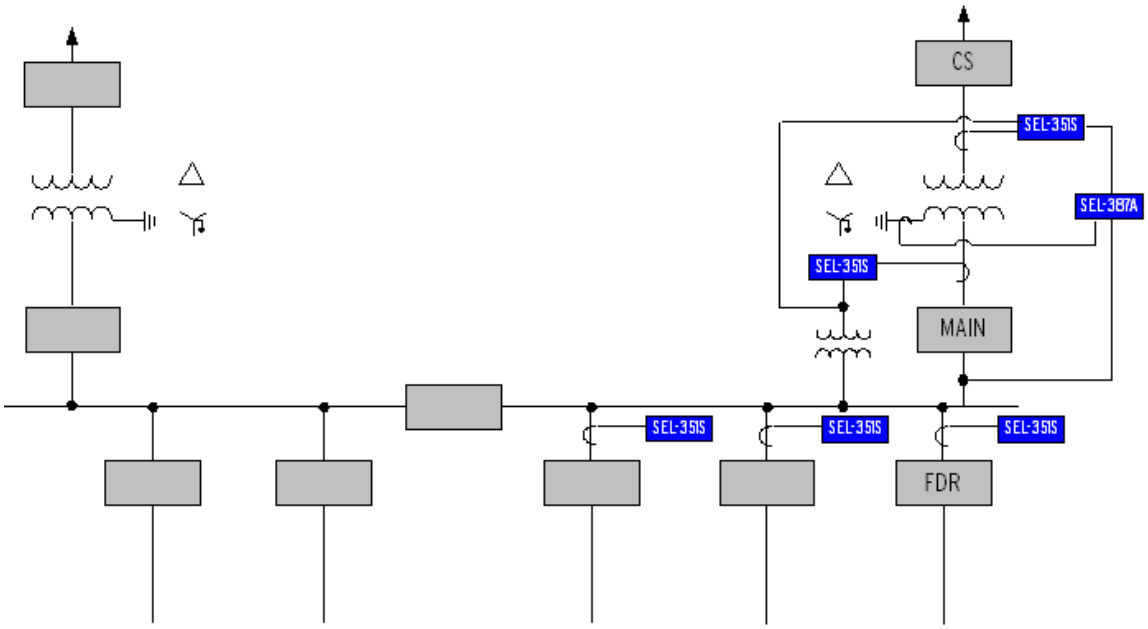
# Transformer Commissioning Worksheet

*Real-World Testing Example: SEL-387A*




SEL-5010 Version Used to Create DB: *Ver 4.8.1.1*

Directory Where Settings are Stored:

Functional Description:

Protection for this transformer consists of two-winding transformer differential with elements 87R and 87U, and wye-winding ground protection using REF logic.

Transformer connections. High side CTs to the 351S and 387A must be re-wired – H1 CT must go to IC (351S) and ICW1 (387A).

**Change Date and Time?** *Yes.*

**Download Settings From Database?** *Yes.*

**Compare Settings in Relay to Database.** No Errors? *Yes.*

**Settings** (insert screen capture here of Group 1, Logic 1, Global, SER, Text and Port):

=>>SHO
Group 1

RID =T1C DIFFERENTIAL
TID =CENTRAL
E87 = Y
EOC1 = N EOC2 = N EOCN = N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```
E49A    = N       E49B    = N
ESLS1   = N       ESLS2   = N       ESLS3   = N

W1CT    = Y       W2CT    = Y
CTR1    = 120     CTR2    = 400
CTRN1   = 1       CTRN2   = 240     CTRN3   = 1
MVA     = 22.0    ICOM    = Y
W1CTC   = 1       W2CTC   = 12
VWDG1   = 68.68   VWDG2   = 12.47

TAP1    = 1.54    TAP2    = 2.55
O87P    = 0.33    SLP1    = 30      SLP2    = OFF
U87P    = 8.0     PCT2    = 15      PCT4    = 15      PCT5    = OFF
TH5P    = OFF     DCRB    = N       HRSTR   = Y

E32I1   =0

Press RETURN to continue
E32I2   =!CTS2
32IOP2  = 2       a02     = 0.10    50GP2   = 0.50
TDURD   = 9.000   CFD     = 60.000

TR1     =87R + 87U
TR2     =REFP2
TR3     =0
TR4     =0
TR5     =0
ULTR1   =!87R * !87U
ULTR2   =!REFP2
ULTR3   =0
ULTR4   =0
ULTR5   =0
52A1    =IN101
52A2    =IN102
52A3    =0
52A4    =0
CL1     =0
Press RETURN to continue
CL2     =0
CL3     =0
CL4     =0
ULCL1   =1
ULCL2   =1
ULCL3   =1
ULCL4   =1
ER      =/50GN2 + /32IE2
OUT101  =TRIP1 + TRIP2
OUT102  =0
OUT103  =0
OUT104  =0
OUT105  =0
OUT106  =0
```


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```
OUT107  =0

=>>SHO G
LER     = 15       PRE     = 4        NFREQ   = 60       PHROT   = ABC
DATE_F  = MDY      SCROLD  = 2        FP_TO   = 15       TGR     = 3
TMPREFA = F        TMPREFB = F
DC1P    = OFF      DC2P    = OFF      DC3P    = OFF      DC4P    = OFF
IN101D  = 0.50     IN102D  = 0.50     IN103D  = 0.50
IN104D  = 0.50     IN105D  = 0.50     IN106D  = 0.50

BKMON1  =0

BKMON2  =0

ETHRU   = N

IAW1    =IAW1
IBW1    =IBW1
ICW1    =ICW1
IAW2    =IAW2
IBW2    =IBW2
ICW2    =ICW2

Press RETURN to continue
IAW4    =IN1
IBW4    =IN2
ICW4    =IN3

SS1     =1
SS2     =0
SS3     =0
SS4     =0
SS5     =0
SS6     =0
LEDA    =OCA + 87E1
LEDB    =OCB + 87E2
LEDC    =OCC + 87E3
LED15   =REFP2
LED16   =REFP2

DP1     =IN101
DP1_1   =CS10 CLOSED     DP1_0   =CS10 OPEN
DP2     =IN102
DP2_1   =M8 CLOSED       DP2_0   =M8 OPEN
DP3     =IN103

Press RETURN to continue
DP3_1   =87T LOCKOUT TRIP DP3_0   =
DP4     =0
DP4_1   =             DP4_0   =
DP5     =0
DP5_1   =             DP5_0   =
DP6     =0
```


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```
DP6_1  =          DP6_0  =
DP7   =0
DP7_1  =          DP7_0  =
DP8   =0
DP8_1  =          DP8_0  =
DP9   =0
DP9_1  =          DP9_0  =
DP10  =0
DP10_1 =          DP10_0 =
DP11  =0
DP11_1 =          DP11_0 =
DP12  =0
DP12_1 =          DP12_0 =
DP13  =0

Press RETURN to continue
DP13_1 =          DP13_0 =
DP14  =0
DP14_1 =          DP14_0 =
DP15  =0
DP15_1 =          DP15_0 =
DP16  =0
DP16_1 =          DP16_0 =
Text Labels:
NLB1   =        CLB1   =     SLB1   =     PLB1   =
NLB2   =        CLB2   =     SLB2   =     PLB2   =
NLB3   =        CLB3   =     SLB3   =     PLB3   =
NLB4   =        CLB4   =     SLB4   =     PLB4   =
NLB5   =        CLB5   =     SLB5   =     PLB5   =
NLB6   =        CLB6   =     SLB6   =     PLB6   =
NLB7   =        CLB7   =     SLB7   =     PLB7   =
NLB8   =        CLB8   =     SLB8   =     PLB8   =
NLB9   =        CLB9   =     SLB9   =     PLB9   =
NLB10  =        CLB10  =     SLB10  =     PLB10  =
NLB11  =        CLB11  =     SLB11  =     PLB11  =
NLB12  =        CLB12  =     SLB12  =     PLB12  =

Press RETURN to continue
NLB13  =        CLB13  =     SLB13  =     PLB13  =
NLB14  =        CLB14  =     SLB14  =     PLB14  =
NLB15  =        CLB15  =     SLB15  =     PLB15  =
NLB16  =        CLB16  =     SLB16  =     PLB16  =

=>>SHO R

SER1   =IN101,IN102,IN103,87R,87R1,87R2,87R3,87U,87U1,87U2,87U3
SER2   =OUT101,TRIP1,TRIP2,REFP2,CTS2,50GC2,50GN2,32IF2,32IR2,32IE2
SER3   =0
SER4   =0

ALIAS1  =NA
ALIAS2  =NA
ALIAS3  =NA
```


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```
ALIAS4  =NA
ALIAS5  =NA
ALIAS6  =NA
ALIAS7  =NA
ALIAS8  =NA
ALIAS9  =NA
ALIAS10 =NA
ALIAS11 =NA
ALIAS12 =NA
ALIAS13 =NA

Press RETURN to continue
ALIAS14 =NA
ALIAS15 =NA
ALIAS16 =NA
ALIAS17 =NA
ALIAS18 =NA
ALIAS19 =NA
ALIAS20 =NA

=>>SHO P 2
Port 2

PROTO   = SEL
SPEED   = 9600     BITS    = 8       PARITY  = N       STOP    = 1
T_OUT   = 0        AUTO    = Y       RTSCTS  = N       FASTOP  = Y
```


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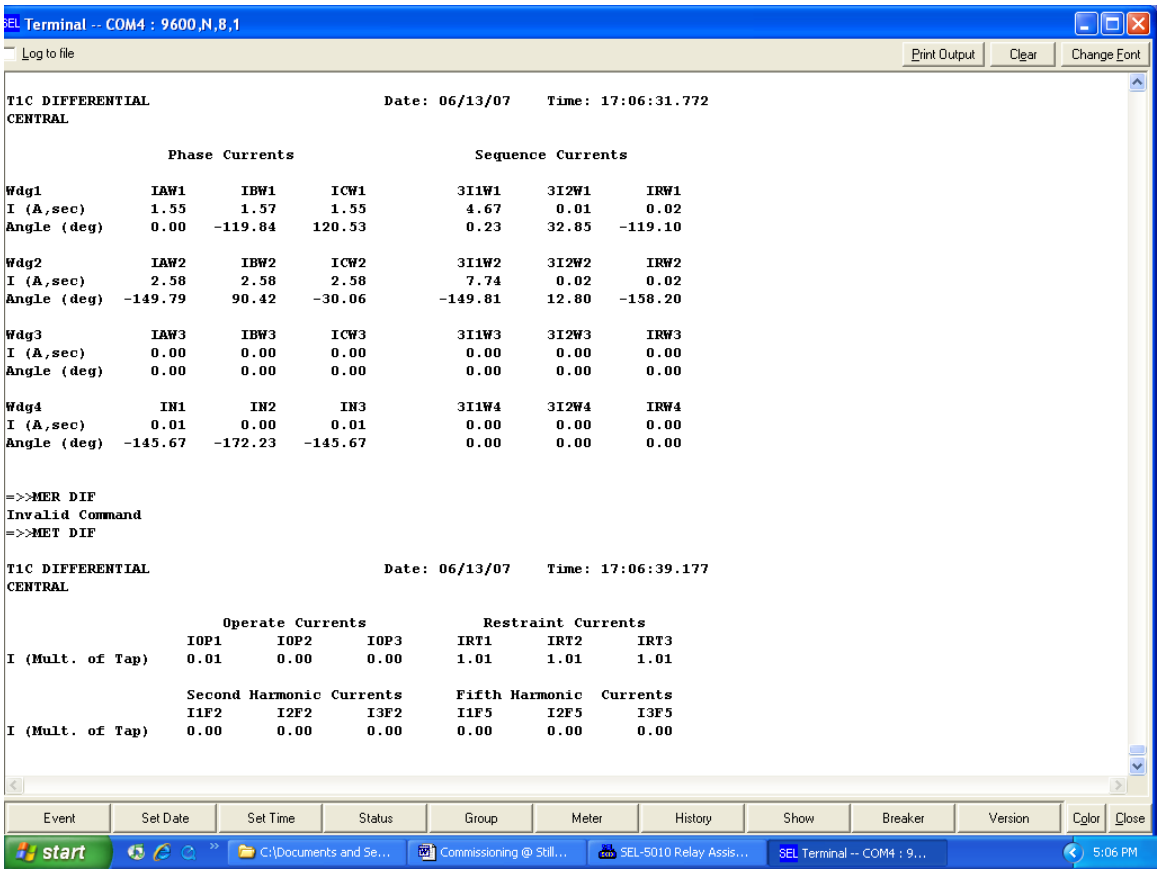
Terminal -- COM4 : 9600,N,8,1
Log to file
Print Output
Clear
Change Font
T1C DIFFERENTIAL Date: 06/13/07 Time: 17:06:31.772
CENTRAL
Phase Currents Sequence Currents
Wdg1 IAW1 IBW1 ICW1 3I1W1 3I2W1 IRW1
I (A,sec) 1.55 1.57 1.55 4.67 0.01 0.02
Angle (deg) 0.00 -119.84 120.53 0.23 32.85 -119.10
Wdg2 IAW2 IBW2 ICW2 3I1W2 3I2W2 IRW2
I (A,sec) 2.58 2.58 2.58 7.74 0.02 0.02
Angle (deg) -149.79 90.42 -30.06 -149.81 12.80 -158.20
Wdg3 IAW3 IBW3 ICW3 3I1W3 3I2W3 IRW3
I (A,sec) 0.00 0.00 0.00 0.00 0.00 0.00
Angle (deg) 0.00 0.00 0.00 0.00 0.00 0.00
Wdg4 IN1 IN2 IN3 3I1W4 3I2W4 IRW4
I (A,sec) 0.01 0.00 0.01 0.00 0.00 0.00
Angle (deg) -145.67 -172.23 -145.67 0.00 0.00 0.00
=>>MER DIF
Invalid Command
=>>MET DIF
T1C DIFFERENTIAL Date: 06/13/07 Time: 17:06:39.177
CENTRAL
Operate Currents Restraint Currents
IOP1 IOP2 IOP3 IRT1 IRT2 IRT3
I (Mult. of Tap) 0.01 0.00 0.00 1.01 1.01 1.01
Second Harmonic Currents Fifth Harmonic Currents
I1F2 I2F2 I3F2 I1F5 I2F5 I3F5
I (Mult. of Tap) 0.00 0.00 0.00 0.00 0.00 0.00
Event
Set Date
Set Time
Status
Group
Meter
History
Show
Breaker
Version
Color
Close
start
C:\Documents and Se...
Commissioning @ Still...
SEL-5010 Relay Assis...
Terminal -- COM4 : 9...
5:06 PM

We applied balanced three-phase currents to high side (W1) and low side (W2). Low-side leads the high-side by 30 deg (in the CT secondaries, HS will lead LS by 150 deg). For magnitudes, we applied 1 pu TAP, i.e. transformer nameplate rating of 22MVA. IOP = 0.

**O87P = 0.33 (Setting)**

Expected pick-up current is 0.33 x 1.73 x TAP 1 or 0.88. Actual pick-up is 0.89 Amps.
Expected pick-up current is 0.33 x 1.5 x TAP 2 or 1.257. Actual pick-up is = 1.28 Amps.

**U87P = 8 (Setting)**

Expected pick-up current is 8 x 1.73 x TAP 1 or 21.3. Actual pick-up is 21.16 Amps.
Expected pick-up current is 8 x 1.5 x TAP 2 or 30.6. Actual pick-up is = 30.36 Amps.


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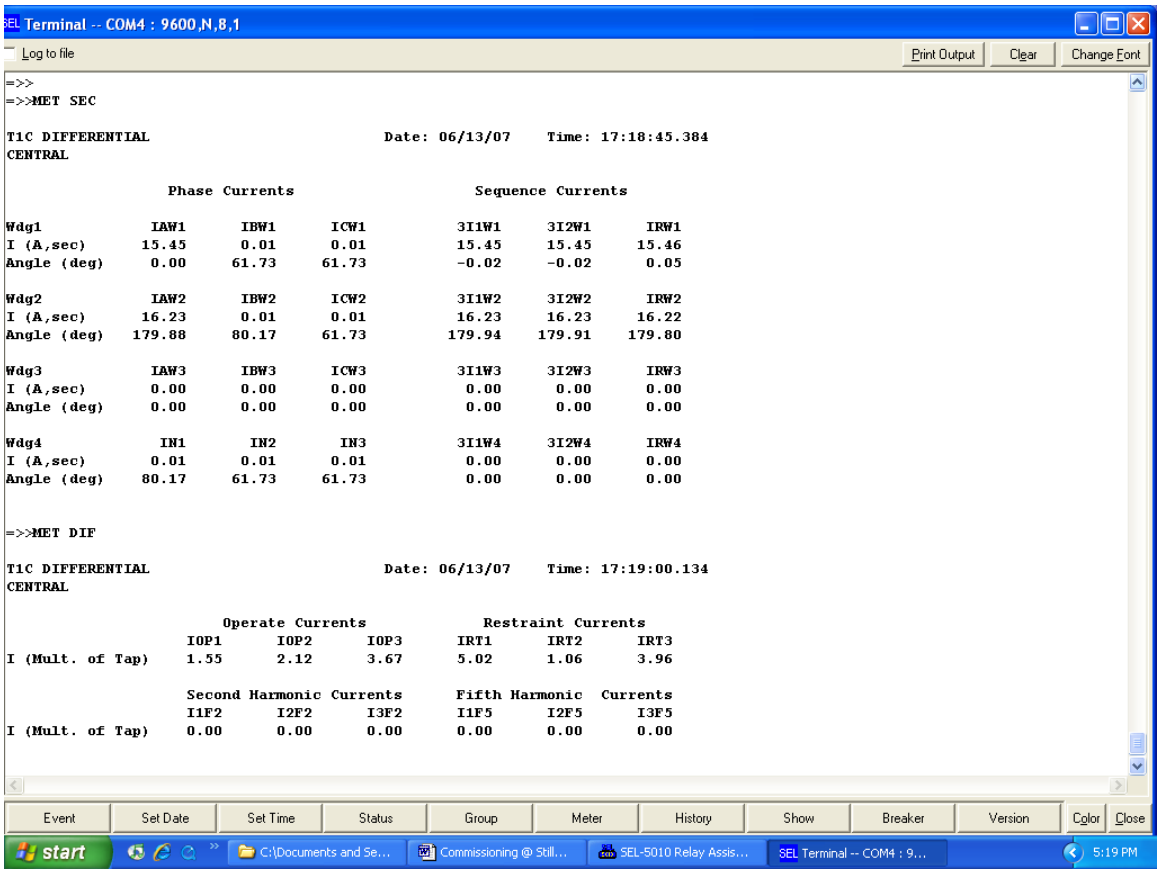
## Slope 1 (30%) Test


Terminal -- COM4 : 9600,N,8,1
Log to file
Print Output
Clear
Change Font
=>>
=>>MET SEC
T1C DIFFERENTIAL Date: 06/13/07 Time: 17:18:45.384
CENTRAL
Phase Currents Sequence Currents
Wdg1 IAW1 IBW1 ICW1 3I1W1 3I2W1 IRW1
I (A,sec) 15.45 0.01 0.01 15.45 15.45 15.46
Angle (deg) 0.00 61.73 61.73 -0.02 -0.02 0.05
Wdg2 IAW2 IBW2 ICW2 3I1W2 3I2W2 IRW2
I (A,sec) 16.23 0.01 0.01 16.23 16.23 16.22
Angle (deg) 179.88 80.17 61.73 179.94 179.91 179.80
Wdg3 IAW3 IBW3 ICW3 3I1W3 3I2W3 IRW3
I (A,sec) 0.00 0.00 0.00 0.00 0.00 0.00
Angle (deg) 0.00 0.00 0.00 0.00 0.00 0.00
Wdg4 IN1 IN2 IN3 3I1W4 3I2W4 IRW4
I (A,sec) 0.01 0.01 0.01 0.00 0.00 0.00
Angle (deg) 80.17 61.73 61.73 0.00 0.00 0.00
=>>MET DIF
T1C DIFFERENTIAL Date: 06/13/07 Time: 17:19:00.134
CENTRAL
Operate Currents Restraint Currents
IOP1 IOP2 IOP3 IRT1 IRT2 IRT3
I (Mult. of Tap) 1.55 2.12 3.67 5.02 1.06 3.96
Second Harmonic Currents Fifth Harmonic Currents
I1F2 I2F2 I3F2 I1F5 I2F5 I3F5
I (Mult. of Tap) 0.00 0.00 0.00 0.00 0.00 0.00
Event
Set Date
Set Time
Status
Group
Meter
History
Show
Breaker
Version
Color
Close
start
C:\Documents and Se...
Commissioning @ Still...
SEL-5010 Relay Assis...
Terminal -- COM4 : 9...
5:19 PM

## REF minimum sensitivity test, 50GP2 (pick-up) –

Expect 0.5 Amps IN2. Apply single phase current to IN2 input. Actual was 0.51 Amps.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**CTS2 test of a02 –** Applied balanced three phase to IW2, then increased IAW2 to create 3I0 current. CTS is originally off, until you cross 0.5 minimum sensitivity. When 3I0 on W2 is > 0.5, but less than 10% of 3I1 on W2, CTS asserts. When 3I0 is increased further, >10% of 3I1 on W2, CTS deasserts.

```
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0

50GC2   50GN2   32IE2   32IR2   32IF2   REFP2   CTS2    *
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0

50GC2   50GN2   32IE2   32IR2   32IF2   REFP2   CTS2    *
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       0       0
1       0       0       0       0       0       1       0

50GC2   50GN2   32IE2   32IR2   32IF2   REFP2   CTS2    *
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
1       0       0       0       0       0       1       0
=>>TAR CTS2

50GC2   50GN2   32IE2   32IR2   32IF2   REFP2   CTS2    *
1       0       0       0       0       0       0       0
  --|
=>>MET SEC

T1C DIFFERENTIAL                        Date: 06/13/07    Time: 17:24:38.580
CENTRAL

                    Phase Currents                  Sequence Currents

Wdg1              IAW1      IBW1      ICW1          3I1W1     3I2W1      IRW1
I (A,sec)         0.01      0.01      0.01           0.00      0.00      0.03
Angle (deg)     -90.00    -90.00    -90.00          30.00     30.00    -90.00

Wdg2              IAW2      IBW2      ICW2          3I1W2     3I2W2      IRW2
I (A,sec)        13.52     10.11     10.11          33.73      3.41      3.41
Angle (deg)     134.55     14.52   -105.47         134.54    134.64    134.58

Wdg3              IAW3      IBW3      ICW3          3I1W3     3I2W3      IRW3
I (A,sec)         0.00      0.00      0.00           0.00      0.00      0.00
Angle (deg)       0.00      0.00      0.00           0.00      0.00      0.00

Wdg4               IN1       IN2       IN3          3I1W4     3I2W4      IRW4
I (A,sec)         0.01      0.01      0.01           0.00      0.00      0.00
Angle (deg)     -90.00    -90.00    -90.00           0.00      0.00      0.00
```

**REF Directional Element –**

To test the angle of the directional element of the REFP2, we applied 1 A 3I0 on W2, and 1A on IN2, out of phase (180 deg between them). This picks up in the reverse direction (32IR2). Then, we rotated the phase angle of the W2 (operate) in reference to the IN2 (polarizing). Boundaries expected were +90 deg and +270 deg. Actual boundaries found were +81 deg and +262 deg.

**Ensure 87T lock out trips when 387A trips –**
Yes.


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## Restricted Earth Fault (REF) Function

The test for the REF function uses two current sources to inject current into two different windings. Small currents are used to demonstrate the sensitivity of the element to internal ground faults. The test assumes a 5 A relay is being used.



The settings for the REF function are these:

E32In = Enabling SELOGIC control equations. Set E32In = 1.
32IOPn = Winding(s) for obtaining the Operate quantity. Set 32IOPn = 1.
a0n = Positive-sequence restraint factor. Use default setting, a0n = 0.1.
50GPn = Residual current sensitivity level. Use default setting, 50GPn = 0.5A.
(n = 1, 2)

Recall that the default CT ratio settings are: CTR1 = 120, and CTRN1 = 80.

**Note:** To use the default setting 50GPn = 0.5, be sure that the ratio CTRmax/CTRNn is not more than 2.0, where CTRmax is the CTR1 or CTR2 setting. Using the default CT ratio settings, the ratio CTRmax/CTRN1 = 120/80 = 1.5. Therefore, the 50GPn setting can remain at 0.5 A.

If the ratio CTRmax/CTRNn is greater than 2.0, set 50GPn equal to 0.25 A times the actual ratio of CTRmax/CTRNn.

**Step 1.** Purpose: Determine the expected time delay for the overcurrent element.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the element settings (i.e., **SHO E32In <ENTER>**).

Calculate the time delay to pickup (tp). Inverse-time elements are calculated using three element settings and the operating time equations shown in ***Section 3: Differential, Restricted Earth Fault, and Overcurrent Elements***. TD is the time-dial setting, and M is the applied multiple of pickup current.

For example, 50GPn = 0.5 A. The REF function operates as a time-overcurrent element with a fixed timing curve (U4) and fixed time dial (0.5). The amount of neutral input current, INn, is part of a ratio that modifies the REF overcurrnt element assertion time as multiples of the 50GPn pickup setting, M = INn/50GPn. The expected operating time is:

$$tp_{REF} = 0.5 \bullet \left( 0.0352 + \frac{5.67}{M^2 - 1} \right)$$

$$tp_{REF} = 0.963 \text{ seconds}$$

**Step 2.** Purpose: Set the Sequential Events Recorder to record the element timing.

Method: Use **SET R SER1 <ENTER>** to set SER1 equal to the element pickup and time-out Relay Word bits (i.e., 50GNn, 32IFn, and REFPn). When prompted, set SER2, SER3, and SER4 to NA. Save the settings.

**Step 3.** Purpose: Connect and apply two single-current test sources to test the REF element.

Method: Connect two single-current test sources as shown in Figure 10.5, but with source current 2 connected to IN1. Set the IAW1 current magnitude to:

$$IAW1 \geq 2 \bullet 50GP1 \bullet CTRN1/CTR1$$




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Using the default CT ratios, IAW1 should be set to at least 2 • 0.5 A • 80/120, or 0.67 A. Set the magnitude of IAW1 to 1 A; set the angle of IAW1 to 180 degrees.

Set the IN1 current at 1 A at zero degrees. Since the currents are opposite in phase, nothing should happen. Verify this as follows:

Execute the **TAR 50** command. Relay Word bits 50GN1, 32IR1, 32IF1, and REFP1 are all in this row. With the currents applied as above, 50GN1 should be 1, and REFP should remain at 0. Bit 32IR1 should be 1, indicating an external (reverse) fault. Bit 32IF1 should be 0.

Change the angle of IAW1 to zero degrees, or any value within about ±80 degrees of INn. The REF element should function. Verify this as follows:

Execute the **TAR 50** command again. 50GN1 should still be 1, REFP1 should be 1 (indicating time-out), 32IR1 should be 0, and 32IF1 should be 1 (indicating an internal, or forward, fault).

**Step 4.** Purpose: Verify the operation time.

Method: Type **SER <ENTER>** to view the SER records. The assertion and deassertion of each element listed in the SER1, 2, 3, and 4 settings are recorded. Subtract the time of assertion of the directional element (32IF1) from the assertion time of the time-out bit (REFP1). This is the operate time, which should be about one second, as calculated above. (50N1 will have remained asserted from earlier in the test, since no change was made to the IN1 current.) **SER C** clears the SER records.

Repeat steps 2–4 to test REF element 2. You can use Winding 1 as reference for REF2; set 32IOP2 = 1. Alternatively, you can use Winding 2 as reference for REF2; set 32IOP2 = 2 and set pickup setting 50GP2 = 0.75. (You must change the 50GP2 pickup setting because the relay default CT ratio CTR2/CTRN2 is 3:1.)

## Differential

The SEL-387A has several components to its differential element. Figure 10.6 gives a representation of the differential characteristic and the plot of each test. Each test only uses Winding 1 and Winding 2 inputs. The differential elements must be enabled with the E87 = Y, settings.


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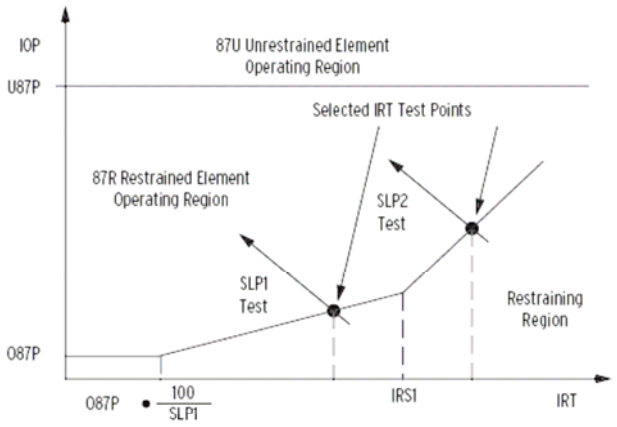


**Figure 10.6: Percentage Restraint Differential Characteristic**

### U87P Unrestrained Differential Element

**Step 1.** Purpose: Verify the expected unrestrained differential element pickup setting.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO U87P<ENTER>**). **Note:** This value is in per unit of tap.

**Step 2.** Purpose: Calculate the required current to pick up the unrestrained differential element.

Method: Calculate the expected pickup for the 87U element by multiplying the U87P setting by the TAP1 and TAP2 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC and W2CTC determine the A constant for the calculations. Use the corresponding TAPn and WnCTC settings for the winding under test.

**CAUTION**

The continuous rating of the current inputs is $3 \bullet I_{nom}$. For this test, you may want to choose low values of U87P and TAPn, in order to limit the required test current to a safe value.

**Step 3.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87U<ENTER>**). The SEL-387A now displays the state of several differential elements in the bottom row of the front-panel LEDs. The 87U bit is the fourth from the left.




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**Step 4.** Purpose: Connect and ramp a single-current test source until the appropriate LED illuminates.

Method: Connect a single-current test source. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87U element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 2, ±5% ±0.02 • $I_{nom}$.

**Step 5.** Purpose: Repeat the test for each phase for each winding if desired.

Method: Repeat steps 1 through 4 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the **TAR F** command is issued.

**Table 10.3: Connection Compensation Factor**

| WnCTC Setting | A |
|---|---|
| 0 | 1 |
| Odd: 1, 3, 5, 7, 9, 11 | $\sqrt{3}$ |
| Even: 2, 4, 6, 8, 10, 12 | 1.5 |

### O87P Differential Element Pickup

**Step 1.** Purpose: Verify the expected restrained differential element minimum pickup setting.

Method: Execute the **SHO** command via the relay front panel or serial port and verify the setting (i.e., **SHO O87P<ENTER>**). **Note:** This value is in per unit of tap.

**Step 2.** Purpose: Calculate the required current to pick up the restrained differential element.

Method: Calculate the expected pickup for the 87R element by multiplying the O87P setting by the TAP1 and TAP2 setting and the compensation constant A shown in Table 10.3. The CT connection compensation settings W1CTC and W2CTC determine the A constant for the calculations. Use the corresponding TAPn and WnCTC settings for the winding under test.

**Step 3.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R<ENTER>**). The SEL-387A now displays the state of several differential elements in the bottom row of the front-panel LEDs. The 87R bit is the right-most LED.


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**Step 4.** Purpose: Connect and ramp a single-current test source until the appropriate LED illuminates.

Method: Connect a single-current test source. Turn on the current test source for the winding under test, and slowly increase the magnitude of current applied until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 2, ±5% ±0.02 • $I_{nom}$.

**Step 5.** Purpose: Repeat the test for each phase for both windings if desired.

Method: Repeat steps 1 through 4 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the **TAR F** command is issued.

### SLP1 Restrained Differential Threshold

**Step 1.** Purpose: Verify the differential characteristic settings and set winding compensation.

Method: Execute the **SHO TAP1<ENTER>** command via the relay front panel or serial port and verify the (TAPn) settings, the Restraint Slope 1 Percentage (SLP1) setting, the Restraint Slope 2 Percentage (SLP2) setting, the restraint current slope 1 limit (IRS1) setting, and the O87P minimum pickup setting.

Execute the **SET W1CTC<ENTER>** command and set the WnCTC settings for the two windings to be used to the same value (0, 1, …, 12). Save the settings.

**Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R<ENTER>**). The SEL-387A now displays the state of several differential elements in the bottom row of the front-panel LEDs. The 87R bit is the right-most LED.

**Step 3.** Purpose: Select a test point on the percentage differential curve in Figure 10.6.

Method: Decide where you want to cross the differential characteristic by picking a restraint value **IRT** which is a vertical line on the graph. Since this test is for the SLP1 threshold, select a point above the O87P intersection point and below IRS1. If SLP2 = OFF, IRS1 and SLP2 are not functional.

$$O87P \bullet 100/SLP1 < IRT < IRS1$$

The value of IOP corresponding to the selected IRT equals the following:

$$IOP = \frac{SLP1}{100} \bullet IRT$$

Both IRT and IOP are in multiples of tap.




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**Step 4.** Purpose: Calculate the expected current for Winding 1 and Winding 2 at the restrained differential element SLP1 threshold for the test point selected above.

Method: Calculate the Winding 1 current for the test using the following formula:

$$IAW1 = IRT \bullet \left( 1 + \frac{SLP1}{200} \right) \bullet TAP1 \bullet A$$

Calculate the Winding 2 current for the test using the following formula:

$$IAW2 = IRT \bullet \left( 1 - \frac{SLP1}{200} \right) \bullet TAP2 \bullet B$$

The A and B connection compensation constants are based on Table 10.3. Since the windings have the same WnCTC setting, the A and B constants will be the same for both windings. The constants must be used to achieve the exact curve point on which we have based the calculations. The TAPn settings can be different for the two windings.

**CAUTION**

The continuous rating of the current inputs is $3 \bullet I_{nom}$. If any currents in this test will exceed this rating, reduce the TAPn values as needed, to prevent possible damage to the input circuits.

**Step 5.** Purpose: Calculate the initial current for Winding 2 for this test.

Method: Calculate the Winding 2 initial current for the test using the following formula:

$$IAW2 = IAW1 \bullet \frac{TAP2}{TAP1} \bullet (B/A)$$

This formula determines the current necessary for zero operating current (IOP = 0) given the IAW1 calculated above.

**Step 6.** Purpose: Connect a single-current test source to A-phase of Winding 1 and a single-current test source to A-phase of Winding 2. Ramp down Winding 2 current until the appropriate LED illuminates.

Method: Connect the two current test sources as shown in Figure 10.5. Turn on the current test source for A-phase of Winding 1 (IAW1) at the value calculated above, **and set the phase angle at zero degrees**. Turn on the current test source for A-phase of Winding 2 (IAW2) at the calculated initial current **and set the phase angle at 180 degrees**. Slowly decrease the magnitude of IAW2 until the 87R1 element asserts. Use 87R2 when injecting current into B-phase and 87R3 when testing C-phase. Note the magnitude of the current applied. It should equal the value calculated in step 4 ±5% ±0.02 • $I_{nom}$.




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**Step 7.** Purpose: Repeat the test for each phase for both windings if desired.

Method: Repeat steps 1 through 6 for each phase. Remember to view the appropriate TARget and apply currents to the appropriate windings. The computer terminal will display the LED labels from left to right when the **TAR F** command is issued.

**Note:** IRS1 must be greater than $\frac{100}{SLP1} \bullet 087P$ if SLP2 is not set to OFF.

### SLP2 Restrained Differential Threshold

**Step 1.** Purpose: Verify the differential characteristic settings and set winding compensation.

Method: Execute the **SHO TAP1<ENTER>** command via the relay front panel or serial port and verify the (TAPn) settings, the Restraint Slope 1 Percentage (SLP1) setting, the Restraint Slope 2 Percentage (SLP2) setting, and the restraint current slope 1 limit (IRS1) setting.

Execute the **SET W1CTC<ENTER>** command and set the WnCTC settings for the two windings to be used to the same value. Save the settings.

Note: For this test, use only WnCTC = 0 or WnCTC = an odd-numbered setting (1, 3, 5, 7, 9, 11). Depending on the value of IRT selected in step 3 below, the even-numbered settings may produce 87R outputs from 87R-2 and 87R-3 before the calculated slope 2 current (below) reaches the curve value for 87R-1. This could lead to erroneous conclusions about the accuracy of the 87R elements.

**Step 2.** Purpose: Display the appropriate Relay Word bit on the front-panel LEDs.

Method: Execute the **TARGET** command (i.e., **TAR F 87R<ENTER>**). The SEL-387A now displays the state of several differential elements in the bottom row of the front-panel LEDs. The 87R bit is the right-most LED.

**Step 3.** Purpose: Select a test point on the percentage differential curve in Figure 10.6.

Method: Decide where you want to cross the differential characteristic by picking a restraint value IRT which is a vertical line on the graph. Since this test is for the SLP2 threshold, select a point above the IRS1 setting.

$$IRT > IRS1$$

The value of IOP that corresponds to the selected IRT is as follows:

$$IOP = \frac{SLP2}{100} \bullet IRT + IRS1 \bullet \left( \frac{SLP1 - SLP2}{100} \right)$$

Both IRT and IOP are in multiples of tap.




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**Step 4.** Purpose: Calculate the expected current for Winding 1 and Winding 2 at the restrained differential element SLP2 threshold for the test point selected above.

Method: Calculate the Winding 1 current for the test using the following formula:

$$IAW1 = \left( IRT \bullet \left( 1 + \frac{SLP2}{200} \right) + IRS1 \bullet \left( \frac{SLP1 - SLP2}{200} \right) \right) \bullet TAP1 \bullet A$$

Calculate the Winding 2 current for the test using the following formula:

$$IAW2 = \left( IRT \bullet \left( 1 - \frac{SLP2}{200} \right) - IRS1 \bullet \left( \frac{SLP1 - SLP2}{200} \right) \right) \bullet TAP2 \bullet A$$

The A connection compensation constant is based on Table 10.3. Since the windings have the same WnCTC setting, the A constant will be the same for both windings. The A constant must be used to achieve the exact curve point on which we have based the calculations. The TAPn settings can be different for the two windings.

**CAUTION**

The continuous rating of the current inputs is $3 \bullet I_{nom}$. If any currents in this test will exceed this rating, reduce the TAPn values as needed, to prevent possible damage to the input circuits.

**Step 5.** Purpose: Calculate the initial current for Winding 2 for this test.

Method: Calculate the Winding 2 initial current by multiplying the Winding 2 expected current calculated above by 110 percent.

IAW2 (initial) = 1.1 • IAW2 (from step 4)

**Step 6.** Purpose: Connect a single-current test source to A-phase of Winding 1 and a single-current test source to A-phase of Winding 2. Ramp down Winding 2 current until the appropriate LED illuminates.

Method: Connect the two current test sources as shown in Figure 10.5. Turn on the current test source for A-phase of Winding 1 (IAW1) at the value calculated above **and set the phase angle to zero degrees**. Turn on the current test source for A-phase of Winding 2 (IAW2) at the calculated starting current **and set the phase angle at 180 degrees**. Slowly decrease the magnitude of current IAW2 until the 87R element asserts. Note the magnitude of the current applied. It should equal the value calculated in step 4 ±5% ±0.02 • $I_{nom}$.

**Step 7.** Purpose: Repeat the test for each phase for each winding if desired.

Method: Repeat steps 1 through 6 for each phase. Remember to view the appropriate TARget and apply current to the appropriate winding. The computer terminal will display the LED labels from left to right when the **TAR F** command is issued.



## Last Steps (After All Testing is Complete) -

Remove AMS Cable, Check Relay Ribbon Connection? *Yes.*

Reset Event History? *Yes.*
Reset SER? *Yes.*
Read As-Left Relay Settings? *Sub 387a as left*
Record Setting File Name? *Sub 387A Settings.mdb*


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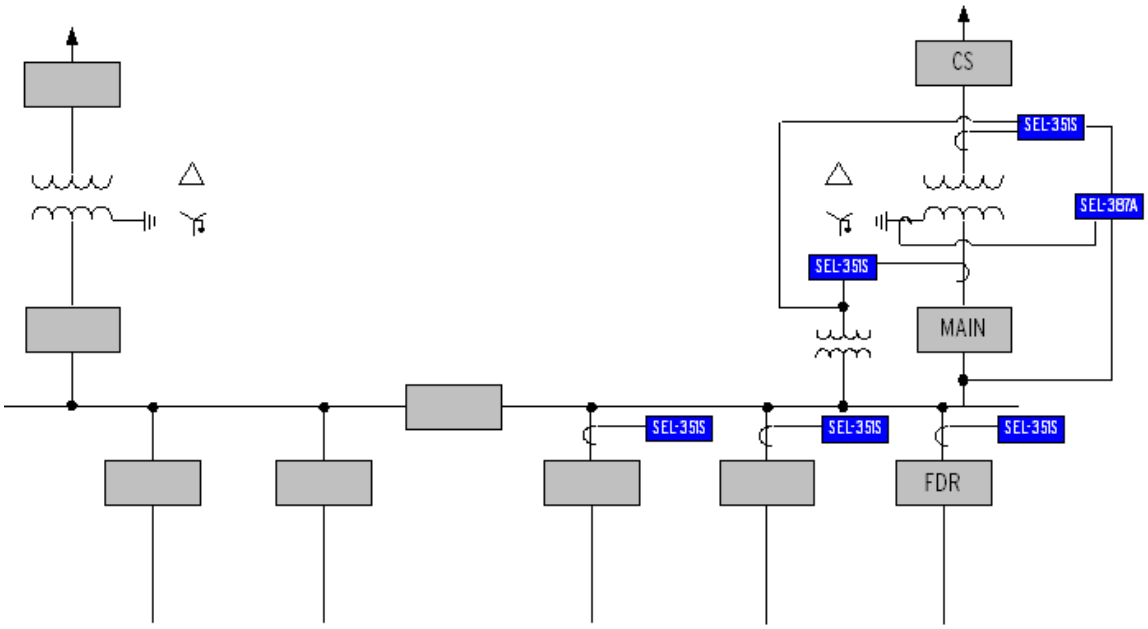
## Feeder Relay Commissioning Worksheet

*Real-World Testing Example: SEL-351S*




**Active ACSELERATOR Database Name:**
*Substation Settings_rev.RDB*
**ACSELERATOR Version Used to Create DB:**
*4.1.10.0*
**Directory Where Settings Stored**: …_rev.rdb

**Functional Description:**
Protection for this feeder consists of non-directional phase 51P, ground 51G, and 3 shot reclosing. Relay trips are via OUT101. Relay auto-reclosing is via OUT102. This relay supplies a block to the fast bus trip scheme by closing an output contact (OUT104) anytime it sees a fault downstream.

51P settings are pick-up of 5 A, U3 curve, TD = 1, and no e/m reset.
51G settings are pick-up of 2.5 A, U3 curve, TD = 1, and no e/m reset.
Reclosing open intervals are 6, 1200, 1800, with 1800 reset from cycle and 300 reset from LO (all settings in cycles).

Three front panel push buttons are used (PB2, RECLOSING DISABLED = AMBER, and PB3, SUPERVISORY DISABLED = AMBER, and LOCK, which supervises the operation of the previous two). Auxiliary red and green push buttons are used to provide local manual trip and close.

SCADA controls are used to enable/disable reclosing, as well as trip (uses OC bit, and OUT106) and close (uses CC bit, and OUT107), when supervisory push button allows. SCADA trip and close are done through SELOGIC variables with 30 cycle drop-out delay. RB1 is used for reclosing enable, and RB2 is used for reclosing disable.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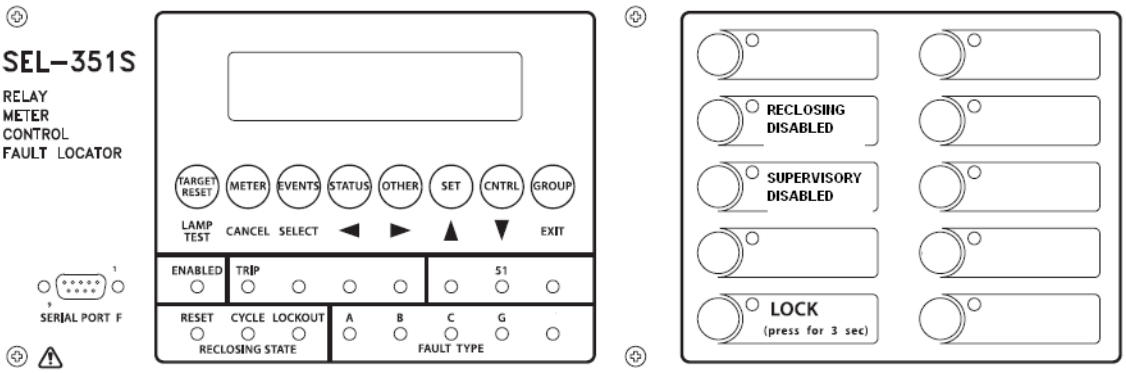
Front panel display messages describe a variety of monitored elements and push button status. Monitored inputs include feeder breaker status (IN101), feeder breaker position (IN102), reclosing and supervisory switch position.




**Download Settings From Database?** *P1-3, G, G1, L1, SER, TEXT.*
**Compare Settings in Relay to Database. No Errors?** *(Read to "As Set" File Name). OK!*
**COPY GROUP 1 TO ALL SIX?** *YES.*
**Replaced Default Front Panel Labels?** YES.
**Settings** *(insert screen capture here of Group 1, Logic 1, Global, SER, Text and Port):*

```
=>>SHO G

Global Settings:
PTCONN = WYE       VSCONN = VS        TGR    = 180.00
NFREQ  = 60        PHROT  = ABC       DATE_F = MDY
FP_TO  = 15        SCROLD = 2         FPNGD  = IG
LER    = 15        PRE    = 4         DCLOP  = OFF       DCHIP  = OFF
IN101D = 0.50      IN102D = 0.50      IN103D = 0.50      IN104D = 0.50
IN105D = 0.50      IN106D = 0.50
EBMON  = Y         COSP1  = 10000     COSP2  = 150       COSP3  = 12
KASP1  = 1.20      KASP2  = 8.00      KASP3  = 20.00
LED12L = Y         LED13L = Y         LED14L = Y         LED15L = Y
LED16L = Y         LED17L = Y         LED18L = Y         LED19L = N
LED20L = N         LED21L = N         LED25L = Y         LED26L = Y
RSTLED = Y
PB9D   = 0.00      PB10D  = 0.00
EPMU   = N

=>>SHO
Group 1
Group Settings:

RID    =FDR1                          TID    =CENTRAL
CTR    = 120       CTRN   = 1
PTR    = 60.00     PTRS   = 1.00      VNOM   = 120.00
Z1MAG  = 0.10      Z1ANG  = 5.00      Z0MAG  = 0.10      Z0ANG  = 5.00
LL     = 0.10
E50P   = N         E50N   = N         E50G   = N         E50Q   = N
E51P   = 1         E51N   = N         E51G   = 1         E51Q   = N
```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```
E32    = N          ELOAD  = N          ESOTF  = N          EVOLT  = N
E25    = N          EFLOC  = N          ELOP   = N          ECOMM  = N
E81    = N          E79    = 3          ESV    = 3          EDEM   = THM

51P1P  = 5.00       51P1C  = U3         51P1TD = 1.00       51P1RS = N
51P1CT = 0.00       51P1MR = 0.00
51G1P  = 2.50       51G1C  = U3         51G1TD = 1.00       51G1RS = N
51G1CT = 0.00       51G1MR = 0.00
79OI1  = 6.00       79OI2  = 1200.00    79OI3  = 1800.00
79RSD  = 1800.00    79RSLD = 300.00     79CLSD = 0.00

DMTC   = 5
PDEMP  = OFF        NDEMP  = OFF        GDEMP  = OFF        QDEMP  = OFF
TDURD  = 9.00       CFD    = 60.00      3POD   = 1.50       50LP   = 0.25
SV1PU  = 0.00       SV1DO  = 0.00       SV2PU  = 0.00       SV2DO  = 30.00
SV3PU  = 0.00       SV3DO  = 30.00

=>>SHO L
SELogic group 1

SELogic Control Equations:
TR     =51P1T + 51G1T
TRCOMM =0
TRSOTF =0
DTT    =0
ULTR   =!(51P1 + 51G1)
PT1    =0
LOG1   =0
PT2    =0
LOG2   =0
BT     =0
52A    =IN101
CL     =0
ULCL   =TRIP
79RI   =TRIP
79RIS  =52A + 79CY
79DTL  =!LT2
79DLS  =79LO

Press RETURN to continue
79SKP  =0
79STL  =TRIP
79BRS  =0
79SEQ  =0
79CLS  =1
SET1   =0
RST1   =0
SET2   =!LT2 * PB2 * LT4 + RB1 * LT3
RST2   =LT2 * PB2 * LT4 + !(79RS + 79CY + 79LO) + RB2 * LT3
SET3   =!LT3 * PB3 * LT4
RST3   =LT3 * PB3 * LT4
SET4   =!LT4 * PB5
RST4   =LT4 * PB5
SET5   =0
RST5   =0
SET6   =0
RST6   =0
```


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```
SET7   =0
RST7   =0
SET8   =0

Press RETURN to continue
RST8   =0
SET9   =0
RST9   =0
SET10  =0
RST10  =0
SET11  =0
RST11  =0
SET12  =0
RST12  =0
SET13  =0
RST13  =0
SET14  =0
RST14  =0
SET15  =0
RST15  =0
SET16  =0
RST16  =0
67P1TC =1
67P2TC =1
67P3TC =1

Press RETURN to continue
67P4TC =1
67N1TC =1
67N2TC =1
67N3TC =1
67N4TC =1
67G1TC =1
67G2TC =1
67G3TC =1
67G4TC =1
67Q1TC =1
67Q2TC =1
67Q3TC =1
67Q4TC =1
51P1TC =1
51N1TC =1
51G1TC =1
51P2TC =1
51N2TC =1
51G2TC =1
51QTC  =1

Press RETURN to continue
SV1    =0
SV2    =OC * LT3
SV3    =CC * LT3
SV4    =0
SV5    =0
SV6    =0
SV7    =0
SV8    =0
```


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```
SV9    =0
SV10   =0
SV11   =0
SV12   =0
SV13   =0
SV14   =0
SV15   =0
SV16   =0
OUT101 =TRIP
OUT102 =CLOSE
OUT103 =0
OUT104 =51P1 + 51G1

Press RETURN to continue
OUT105 =0
OUT106 =SV2T
OUT107 =SV3T
LED1   =0
LED2   =!LT2
LED3   =!LT3
LED4   =0
LED5   =!LT4
LED6   =0
LED7   =0
LED8   =0
LED9   =0
LED10  =0
LED12  =TRIP
LED13  =0
LED14  =0
LED15  =0
LED16  =0
LED17  =51P1T + 51G1T
LED18  =0

Press RETURN to continue
LED19  =79RS
LED20  =79CY
LED21  =79LO
LED25  =51G1
LED26  =0
DP1    =IN101
DP2    =IN102
DP3    =LT2
DP4    =LT3
DP5    =0
DP6    =0
DP7    =0
DP8    =0
DP9    =0
DP10   =0
DP11   =0
DP12   =0
DP13   =0
DP14   =0
DP15   =0
```


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```
Press RETURN to continue
DP16   =0
SS1    =1
SS2    =0
SS3    =0
SS4    =0
SS5    =0
SS6    =0
ER     =/51P1 + /51G1
FAULT  =51P1 + 51G1
BSYNCH =1
CLMON  =0

BKMON  =0
E32IV  =0
TMB1A  =0
TMB2A  =0
TMB3A  =0
TMB4A  =0
TMB5A  =0
TMB6A  =0
TMB7A  =0

Press RETURN to continue
TMB8A  =0
TMB1B  =0
TMB2B  =0
TMB3B  =0
TMB4B  =0
TMB5B  =0
TMB6B  =0
TMB7B  =0
TMB8B  =0

=>>SHO R

Sequential Events Recorder trigger lists:
SER1   =51P1,51P1T,51G1,51G1T,SH0,SH1,SH2,SH3,79LO,79CY,79RS,52A
SER2   =OUT101,OUT102,OUT104,OUT106,OUT107,IN101,IN102,IN103,IN104
SER3   =OC,CC,SV2,SV3,SV2T,SV3T,TRIP,CLOSE

Load Profile settings:
LDLIST =0
LDAR   = 15

=>>SHO T

Text Labels:
NLB1   =              CLB1   =        SLB1   =        PLB1   =
NLB2   =              CLB2   =        SLB2   =        PLB2   =
NLB3   =              CLB3   =        SLB3   =        PLB3   =
NLB4   =              CLB4   =        SLB4   =        PLB4   =
NLB5   =              CLB5   =        SLB5   =        PLB5   =
NLB6   =              CLB6   =        SLB6   =        PLB6   =
NLB7   =              CLB7   =        SLB7   =        PLB7   =
NLB8   =              CLB8   =        SLB8   =        PLB8   =
NLB9   =              CLB9   =        SLB9   =        PLB9   =
```


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```
NLB10  =               CLB10  =        SLB10  =        PLB10  =
NLB11  =               CLB11  =        SLB11  =        PLB11  =
NLB12  =               CLB12  =        SLB12  =        PLB12  =
NLB13  =               CLB13  =        SLB13  =        PLB13  =
NLB14  =               CLB14  =        SLB14  =        PLB14  =
NLB15  =               CLB15  =        SLB15  =        PLB15  =
NLB16  =               CLB16  =        SLB16  =        PLB16  =
DP1_1  =BREAKER CLOSED   DP1_0  =BREAKER OPEN

Press RETURN to continue
DP2_1  =BKR RACKED IN    DP2_0  =BKR RACKED OUT
DP3_1  =RECLOSE ENABLED  DP3_0  =RECLOSE DISABLED
DP4_1  =SUPERVISORY ON   DP4_0  =SUPERVISORY OFF
DP5_1  =                 DP5_0  =
DP6_1  =                 DP6_0  =
DP7_1  =                 DP7_0  =
DP8_1  =                 DP8_0  =
DP9_1  =                 DP9_0  =
DP10_1 =                 DP10_0 =
DP11_1 =                 DP11_0 =
DP12_1 =                 DP12_0 =
DP13_1 =                 DP13_0 =
DP14_1 =                 DP14_0 =
DP15_1 =                 DP15_0 =
DP16_1 =                 DP16_0 =
79LL   =SET RECLOSURES 79SL   =RECLOSE COUNT


=>>SHO P 2
Port 2

PROTO  = SEL
SPEED  = 9600      BITS   = 8         PARITY = N         STOP   = 1
T_OUT  = 0         AUTO   = Y         RTSCTS = N         FASTOP = Y

=>>
```

**Metering Check** *(insert screen capture here):*

CTR = 120
Inom = 5 A
PTR = 60
Vnom = 120 V Line-Neutral
With 5A and 120V, 3PH, Balanced Applied


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```
=>>METER                 ■

FDR1                                    Date: 06/12/07    Time: 11:36:34.636
CENTRAL
                      A          B          C          N          G
I MAG (A)       121.783    122.015    119.450      0.000      3.553
I ANG (DEG)     -10.62    -130.02     109.65     -66.79     -72.61

                      A          B          C          S
V MAG (KV)        7.289      7.284      7.288      0.000
V ANG (DEG)        0.00    -120.02     119.98     -66.75

                      A          B          C         3P
MW                0.872      0.875      0.856      2.604
MVAR              0.164      0.154      0.156      0.474
PF                0.983      0.985      0.984      0.984
                    LAG        LAG        LAG        LAG

                     I1        3I2        3I0         V1         V2        3V0
MAG             121.082      1.371      3.553      7.287      0.001      0.007
ANG    (DEG)     -10.33      60.60     -72.61      -0.01     -12.20      69.07

FREQ (Hz)       60.00                  VDC (V)        18.8

=>>
```

**Test Manual Close?** *YES (red push button)*

**Does Position Indicator Work (RED LED)?** *YES*

**Test Manual Trip?** *YES (green push button)*

**Does Position Indicator Work (GRN LED)**? *YES*

**Test Pick-Ups**

Use Target Command.

51P = 5 A expected. Actual? *4.99 A.*
(Inject A phase)

When Current Applied, Does Relay Send Fast Bus Block?
Use Ohm Meter, Does OUT104 Close When 51P Asserts? *Yes.*
Use Target Command at Local Bus Main, Does IN104 Assert? *YES.*
Use Target Command at Remote Bus Main, Does IN104 Assert with Bus Tie Closed? *Yes.*

51G = 2.5 A expected. Actual? *2.52 A.*
(Inject B phase)

When Current Applied, Does Relay Send Fast Bus Block?
Use Ohm Meter, Does OUT104 Close When 51G Asserts? *YES.*
Use Target Command at Local Bus Main, Does IN104 Assert? *YES.*
Use Target Command at Remote Bus Main, Does IN104 Assert with Bus Tie Closed? *Yes.*

**Test Time and Curve:**

Use SER.

@ 3 x times Tap (15A), Expected 51P Time = 0.5813 sec. Actual? *0.581 SEC.*
(Inject C Phase)


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@ 3 x times Tap (7.5A), Expected 51G Time = 0.5813 sec. Actual? *0.572 SEC.*
(Inject 2.5 @ 0 deg on A,B,C Phases)

| | |
|---|---|
| U3 (Very Inverse) | $t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$ |

**Reclosing Test (Use SER, and Breaker)**

Close Breaker from Lock-Out. Reset time = 5 sec? *Yes.*

1. Once Reset, Apply Fault at > 3xPU.
2. When Breaker Opens, Stop Current.
3. When Breaker Recloses, Reapply Current.
4. Repeat Until Relay Trip to LOCKOUT (4 Trips).
5. Use SER. Check Open Intervals?
   a. 79OI1 = 6 cycles *5.4 Cycles*
   b. 79OI2 = 1200 cycles (20 Sec) *19.98*
   c. 79OI3 = 1800 cycles (30 Sec) *29.99*
6. Repeat 1-2, Reset Time (1800)?*30 Sec*

**Test Inputs**

Change State of Breaker.
Does TARGET Command Follow IN101 Correctly? IN101 = 1 = Breaker Closed,
IN101 = 0 = Breaker Open? *Yes.*
Does Front Panel Display Message Correctly Follow Breaker Status? *Yes.*

Rack Breaker In and Out.
Does TARGET Command Follow IN102 Correctly? IN102 = 1 = Breaker racked IN, IN102 = 0 = Breaker racked out? *Yes.*
Does Front Panel Display Message Correctly Follow Breaker Position? *Yes.*

**Test SCADA Control**

Is Supv Disabled LED AMBER in Disabled Position? *YES*
Does Front Panel Message Follow? *YES*

Assert OC Bit.
Does BKR Open (when Supv is Enabled)? *YES*
Does BKR Not Open (When Supv is Disabled)? *YES*
Use SER.
Does OUT106 Remain Closed for 0.5 sec? Yes. *0.502 Sec.*

Assert CC Bit.
Does BKR Close (when Supv is Enabled)? *YES*
Does BKR Not Close (When Supv is Disabled)? *YES*
Use SER.


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Does OUT107 Remain Closed for 0.5 sec?
Yes. *0.511 Sec.*
Is Reclosing Disabled LED AMBER in Disabled Position? *YES.*
Does Front Panel Message Correctly Follow Reclosing Push Button State? *YES.*
Manually Close Breaker, Allow 79RS to Assert.

Manually Enable and Disable 79 Using PB2. Does Relay Go To Lock-Out, and Return Following PB2? *Yes.*

Assert RB1 (79 on) and RB2 (79 off) Bits Using CON Command on SCADA Port. Does Relay Go To Lock-Out, and Return Following RB Operation? Yes.

**Test Alarm Contact?** *Yes.*

**Last Steps (After All Testing is Complete) -**
Have Drawings Been Highlighted (All Inputs/Outputs Tested) and Redlined (Changes)? *Yes.*

Remove AMS Cable, Check Relay Ribbon Connection? *Yes.*
Reset Event History? *Yes.*

Reset SER? *Yes.*
Read As-Left Relay Settings? *FDR#1_rev_As Left*
Record Setting DB? *Settings_rev.RDB*


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